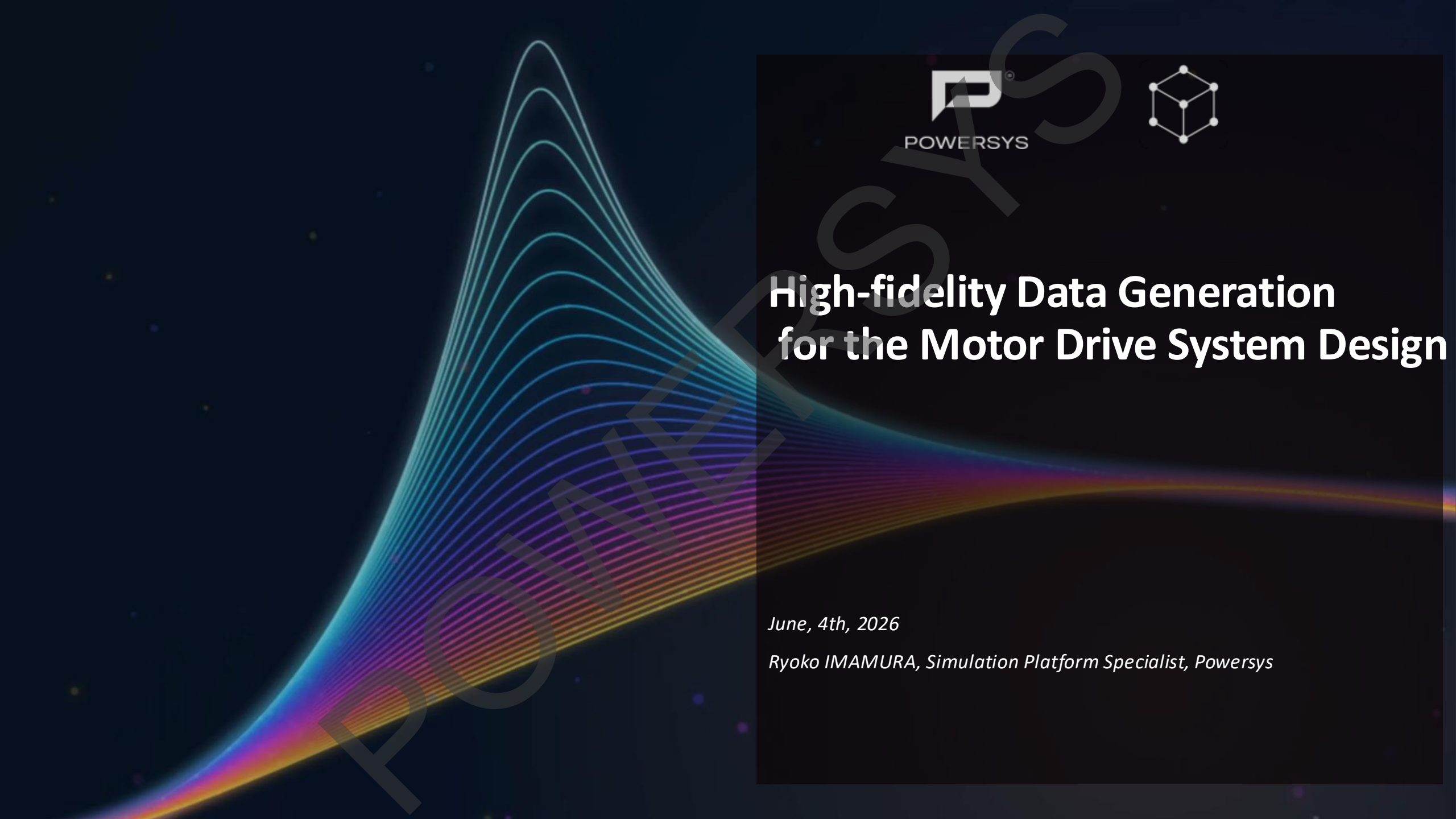
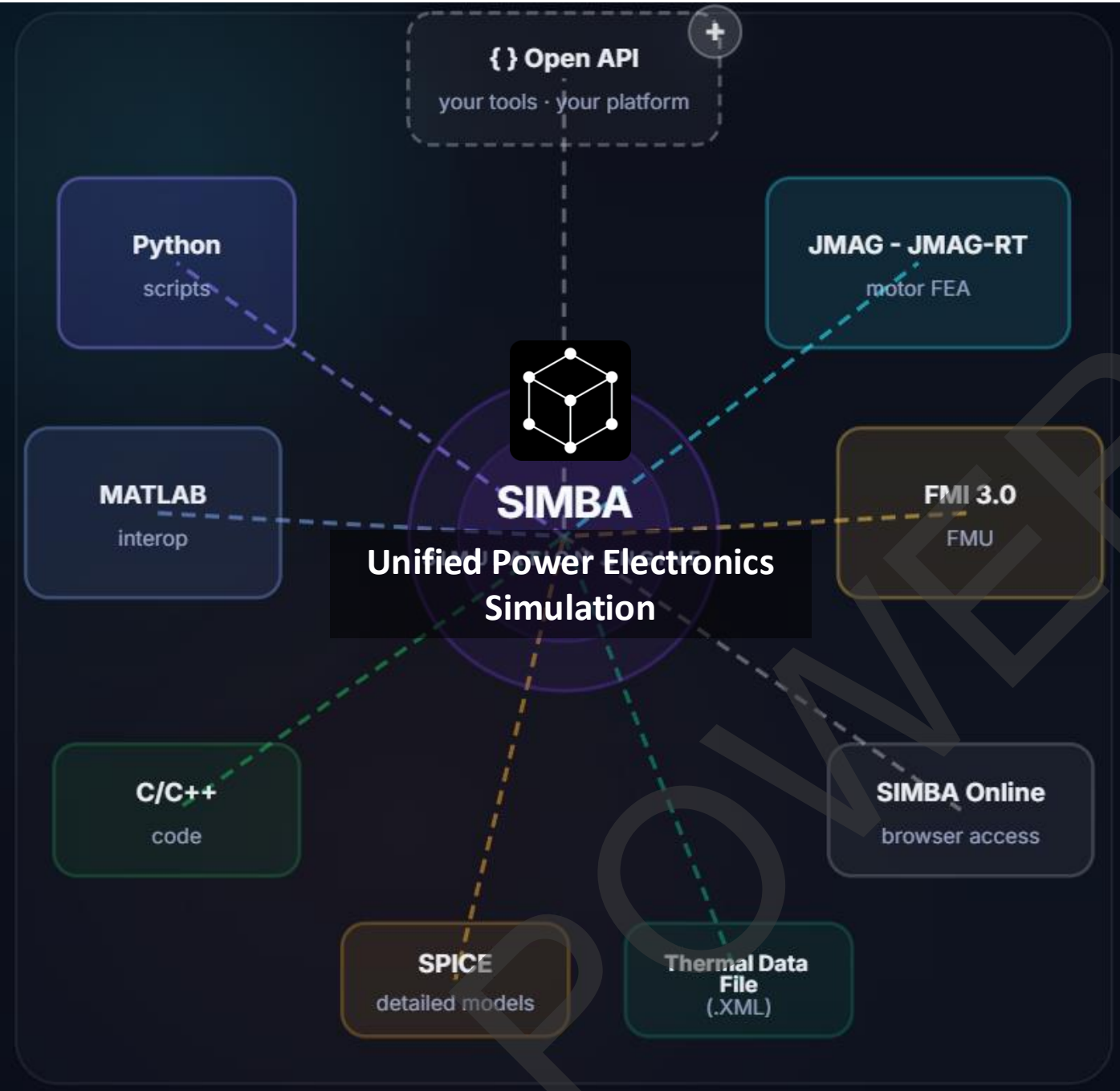


High-fidelity Data Generation for the Motor Drive System Design

June, 4th, 2026

Ryoko IMAMURA, Simulation Platform Specialist, Powersys

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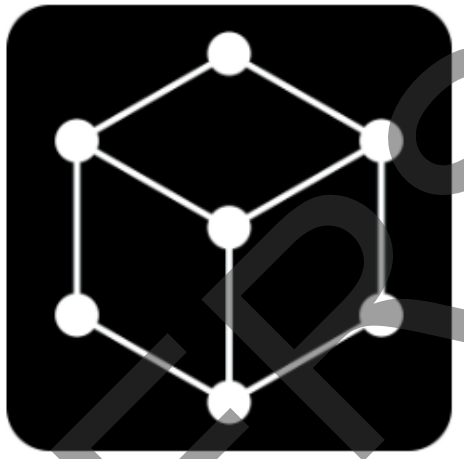
All-in-one power electronics simulation software, SIMBA

SIMBA is a power electronics simulation software from Powersys, a specialist team in electrification.

SIMBA brings system-level exploration, detailed device modeling, and workflow automation together so engineering teams can move from concept to validated design without changing tools.

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SIMBA Assistant



Type your message here...

Build 48V/12V DC-DC Buck-Boost Converter

Build 50kW 3-phase PMSM Drive with SPWM

Build a 6-phase inverter

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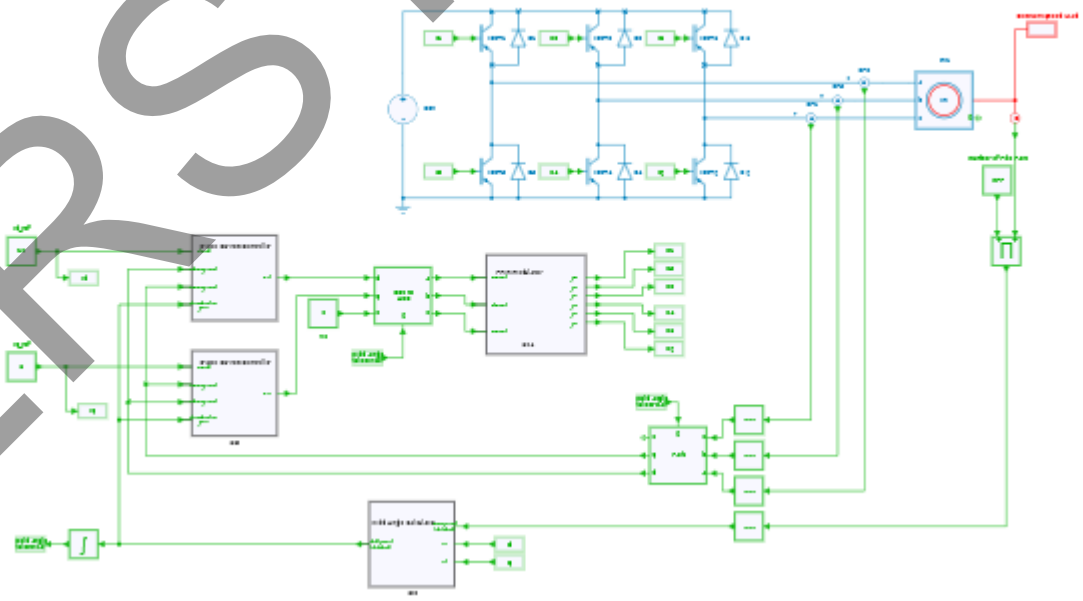
SIMBA Assistant Demo

From a natural-language request to a runnable SIMBA Python script and make plots

LIVE PROMPT

Run the design “IM Drive – Field Oriented Control” with Id_ref = 12, Iq_ref = 4 and make 2 plots. First plot shows Measured Current – D, Measured Current – Q, Id_ref, and Iq_ref. The second plot shows torque.

Quickly automate result extraction and visualization without manually writing the Python boilerplate.



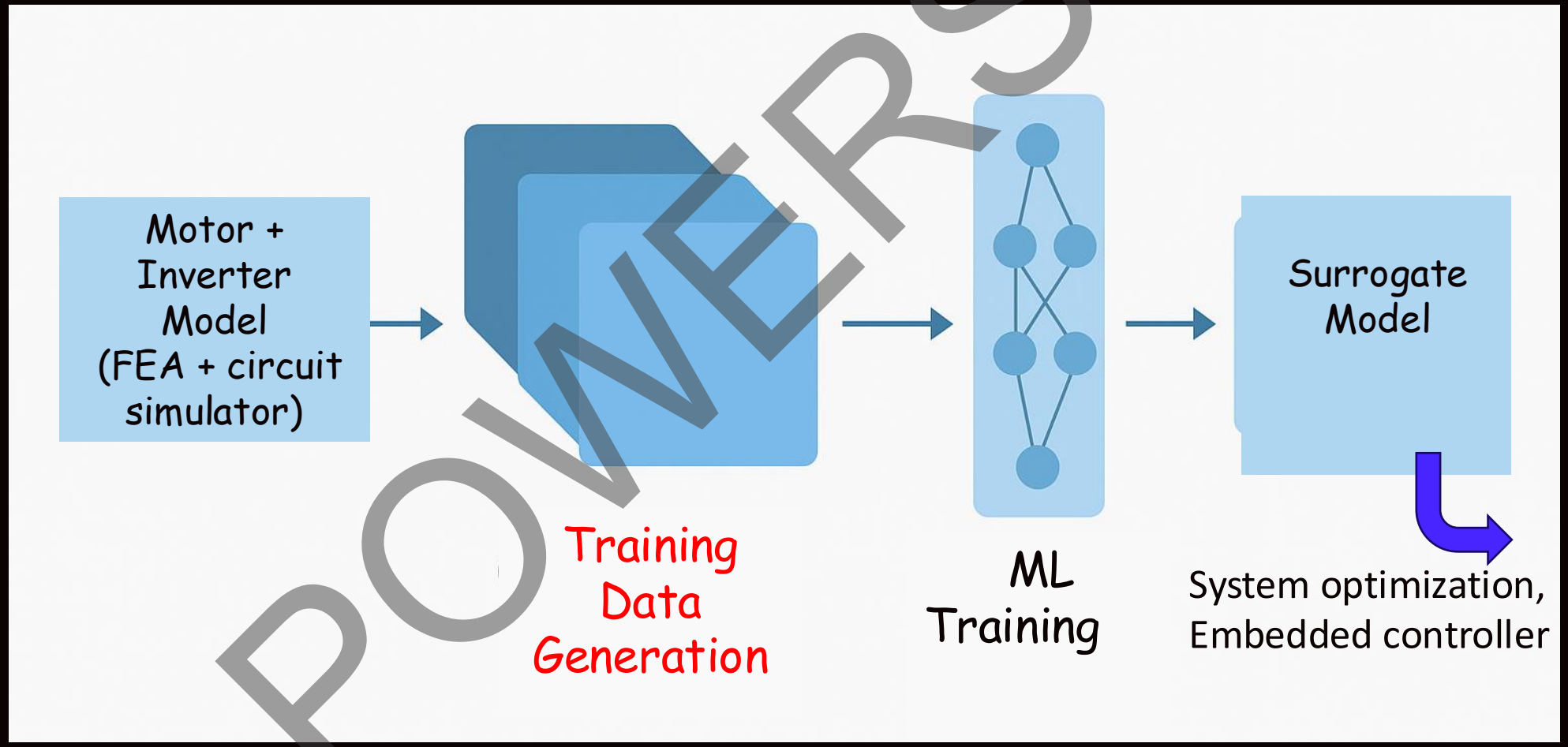
Natural language → **Python script** → **Simulation Run** → **Plot**

Prompt | Created and debugged | Automatically | Steady-State XY Plot

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For Successful Machine Learning (ML) & Data Driven Design

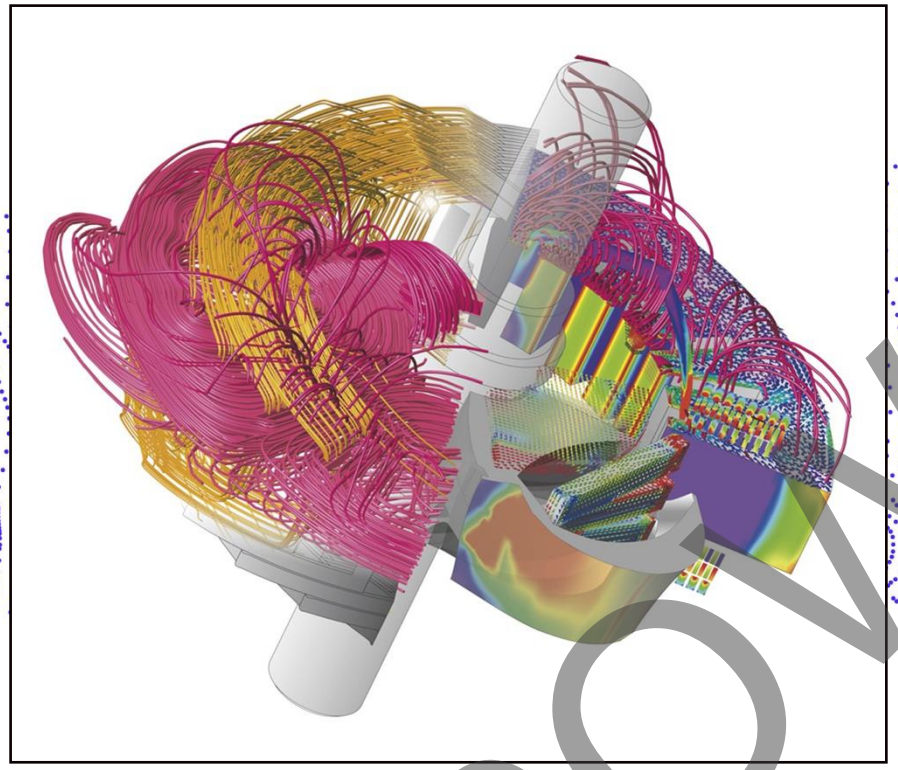
In the era of ML and data-driven design, requirements for skilled engineers are shifting to orchestrate simulations across multiple dimensions to generate large high-quality simulation data as fast as possible.



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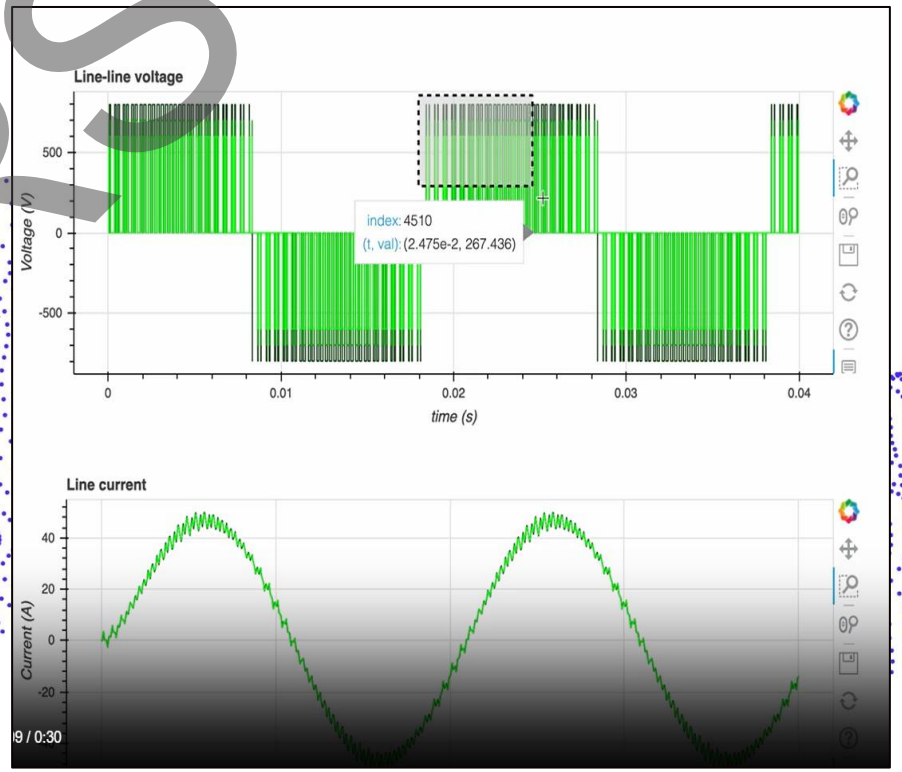
Electric Drive Design Solved: Motor Meets Inverter

Electromagnetics



Spatial harmonics,
Leakage flux,
AC copper loss,
High frequency iron loss,
Time constant: ~10usec

Power Electronics



Harmonics distortion,
Elector magnetic interference,
Conduction loss,
Switching loss …
Time constant: ~10nsec

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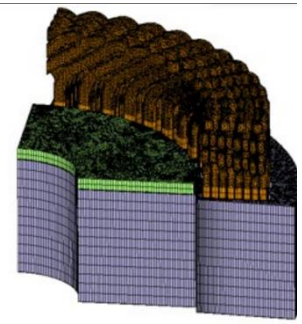
AGENDA

1. High-quality Data Generation
   - EM Analysis Data Quality – Loss Study
   - Data Quality Enhancement by High Fidelity Inverter Model
   - Challenges in High-quality Data Generation
2. Speed Performance Enhancement
3. Large Scale Data Generation
4. Conclusions

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EM Analysis Data Quality – Loss Study

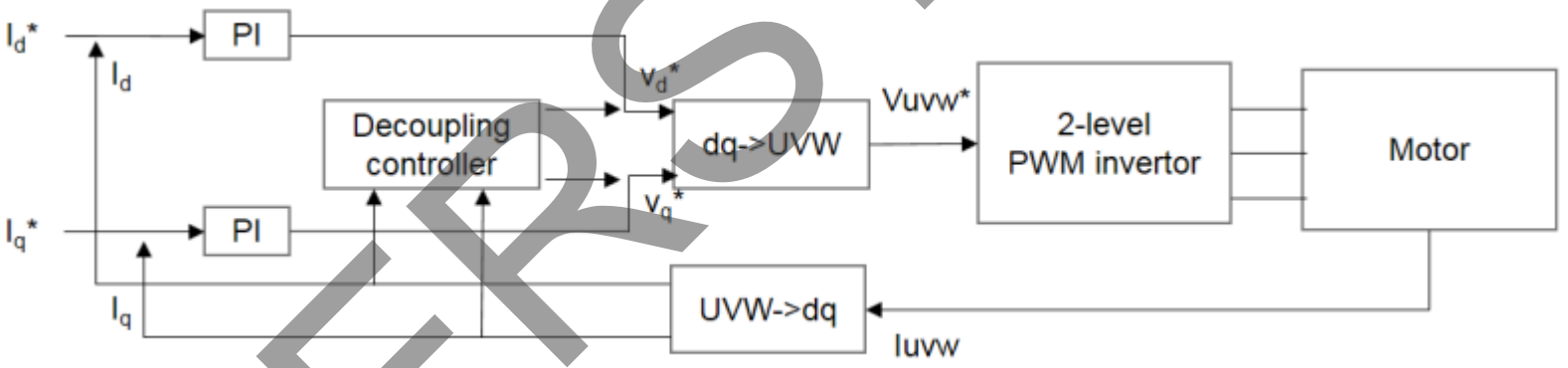
- Comparison of Efficiency Map with Measurement considering the PWM effects (JMAG W-Mo-114)



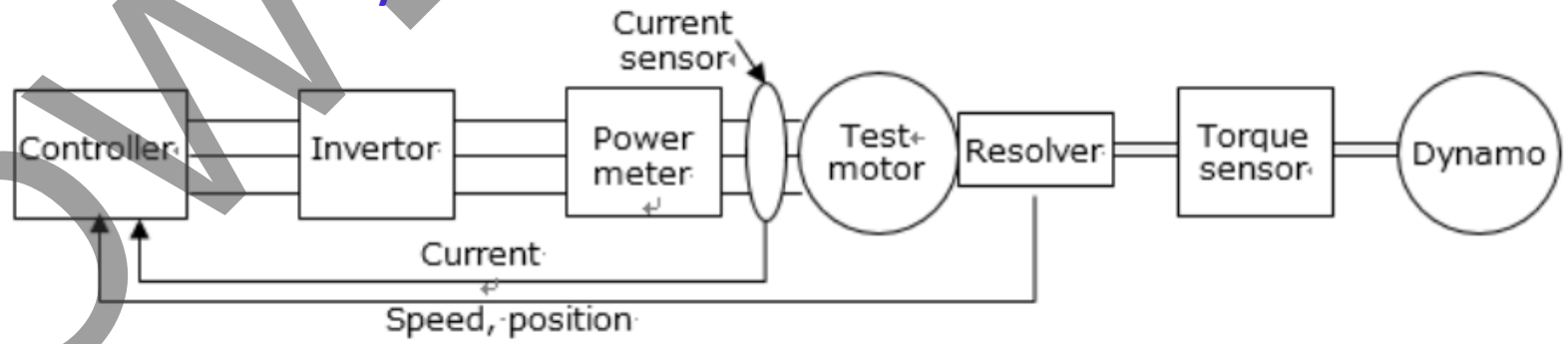


Number of rotor poles	8
Number of stator slots	48
Stator core outer diameter	125 mm
Air-gap length	0.6 mm
Axial length of core	51.8 mm
Maximum rotation speed	15,000 r/min
Maximum torque / output	30 Nm, 10 kW
Maximum armature current	150 A_{rms}(Maximum), 75 A_{rms} (Rated)
Cooling method	Water cooling
Number of armature coil-turn	8 turn / slot
Armature winding connection	4 series - 2 parallel
Conductor cross section	4.2 mm^2 / coil
Core material	35H-EA (Nippon Steel & Sumitomo metal)
Magnet material	N48TS-GR (Shinetsu chemical)
Endplate material	SUS304 (thickness: 2.5 mm)

Control System



Measurement System



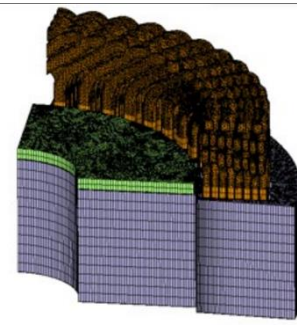
- Measurement was performed by a collaborator, SUZUKI MOTOR Corporation.
- FEA Analysis was performed by JSOL

POWERSYS

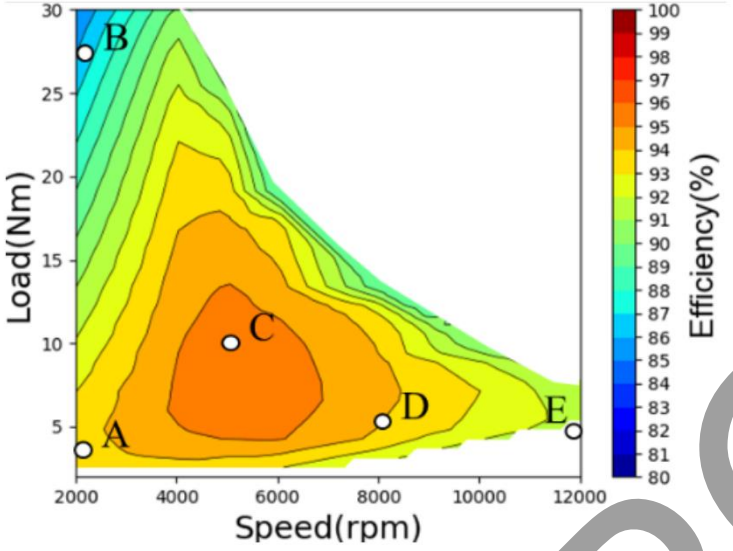
H. Sano et al., "Loss Analysis of a Permanent Magnet Traction Motor in a Finite Element Analysis based Efficiency Map," 2020 International Conference on Electrical Machines (ICEM), Gothenburg, Sweden, 2020, pp. 2301-2306,

EM Analysis Data Quality – Loss Study

- Comparison of Efficiency Map with Measurement considering the PWM effects (JMAG W-Mo-114)







Loss component (W)	A	B	C	D	E
Core loss (fundamental)	8.7	19.6	49.5	75.5	144.4
Core loss (PWM)	6	9.1	9.9	10.7	5.4
AC copper loss (in slot)	1.5	28.9	14.5	26.6	77
AC copper loss (coil end)	0.1	4.6	1.6	3	9.5
Eddy current loss in magnet	1.9	12.3	5	5.7	6.3
Surface eddy current loss	0.5	0.5	3.4	8.8	19.7
Core loss (Degradation)	1.6	2.3	3.8	8.8	10.3
Core loss (Stress)	3.5	7.1	11.2	14.1	17.6
DC copper loss	10.9	978.5	155.5	174.4	252.1
Total loss (simulation)	34.9	1063.1	254.4	327.6	542.3
Measurement	38.5	1002.1	265.6	320.3	562.5

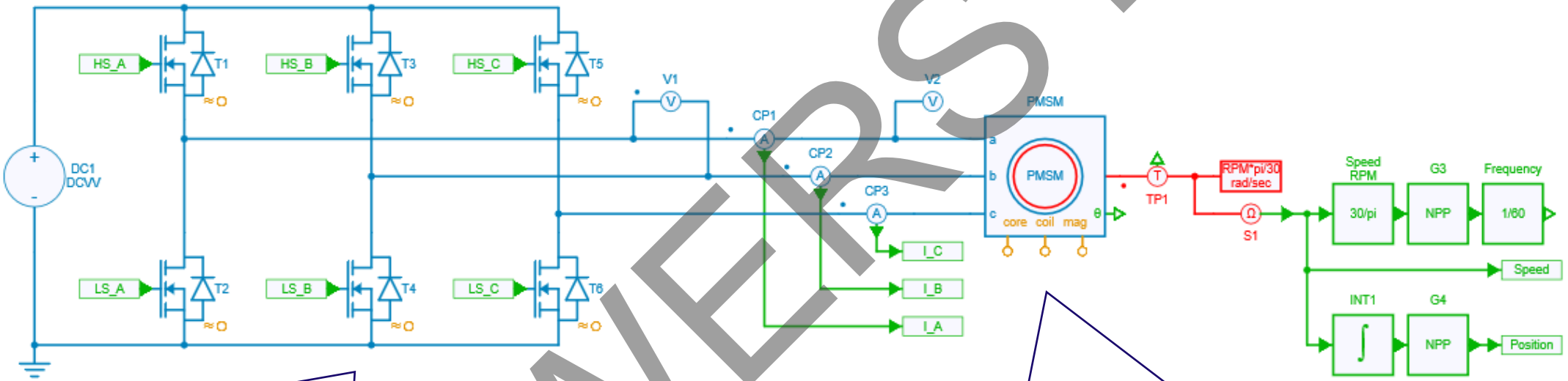
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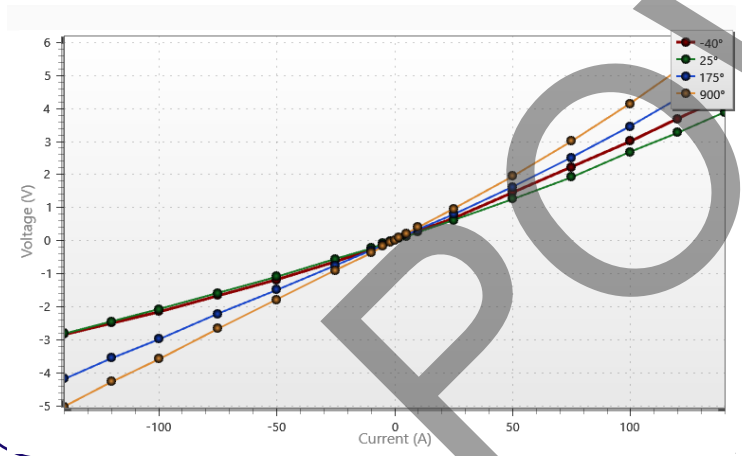
H. Sano et al., "Loss Analysis of a Permanent Magnet Traction Motor in a Finite Element Analysis based Efficiency Map," 2020 International Conference on Electrical Machines (ICEM), Gothenburg, Sweden, 2020, pp. 2301-2306,

Quality Enhancement by High Fidelity Inverter Model

x

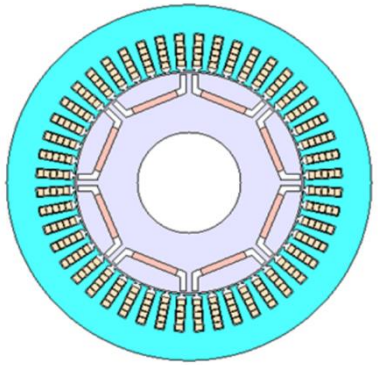
- Drive System Loss Study with Multiple Modulation Techniques (SIMBA Technical Resource 44)





SiC MOSFET (Wolfspeed, C3M0025065D)

- SIMBA Device thermal model
- Switching loss
- Conduction loss



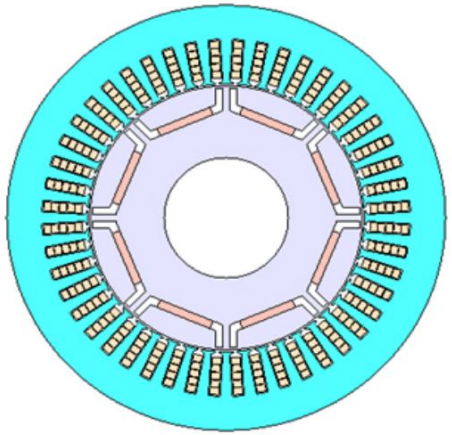
8-poles 48-slots PMSM

- FEA base LUT (JMAG-RT)
- Spatial harmonics
- High frequency iron loss
- AC copper loss

POWERSYS

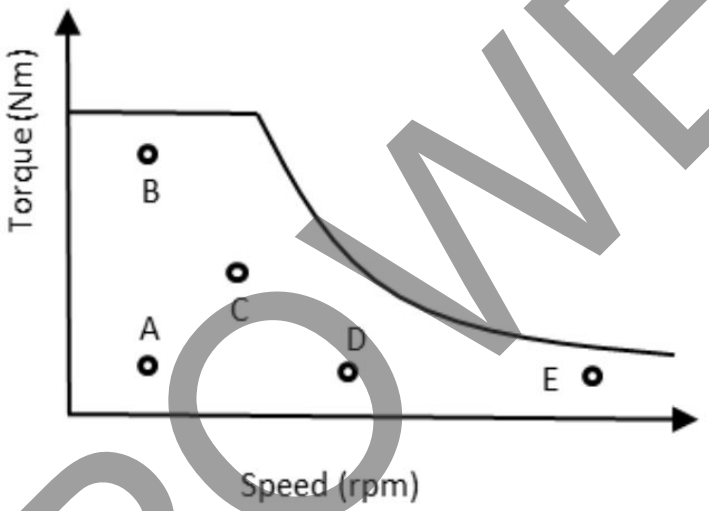
Quality Enhancement by High Fidelity Inverter Model

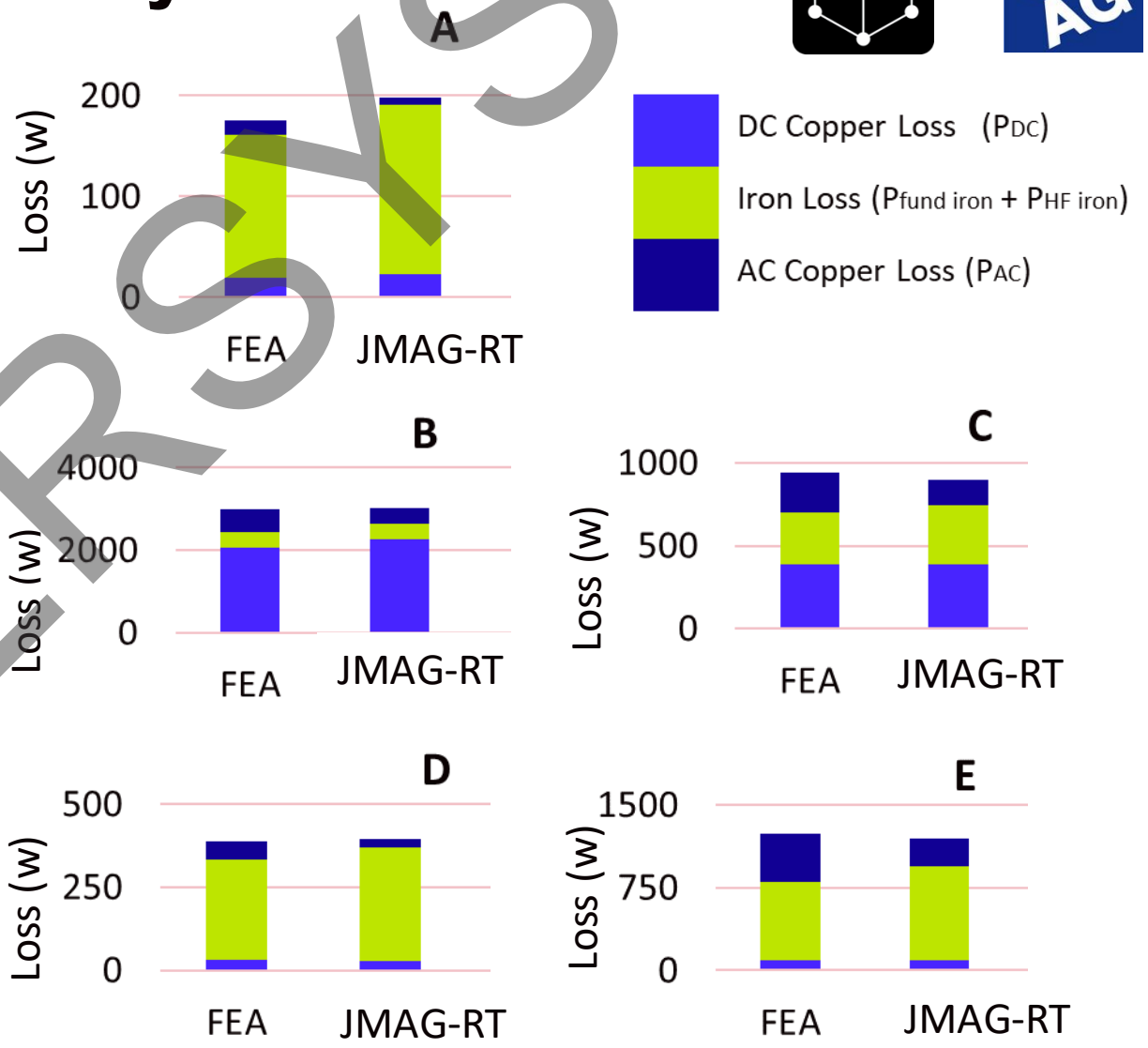
x



# of poles/slots	8/48
Output	80 kW
DC Voltage	600 V
Maximum current	250A
Carrier Frequency	6 kHz

Operating point	Speed (RPM)	Torque (Nm)
A	2000	20
B	2000	250
C	3000	100
D	4000	20
E	8000	20

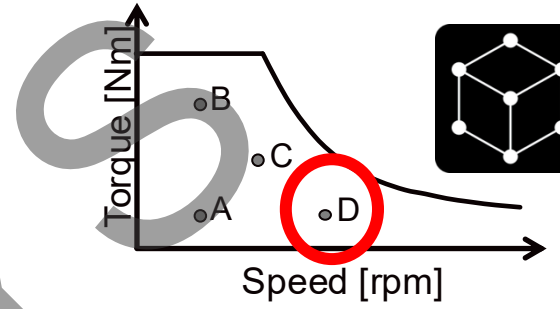




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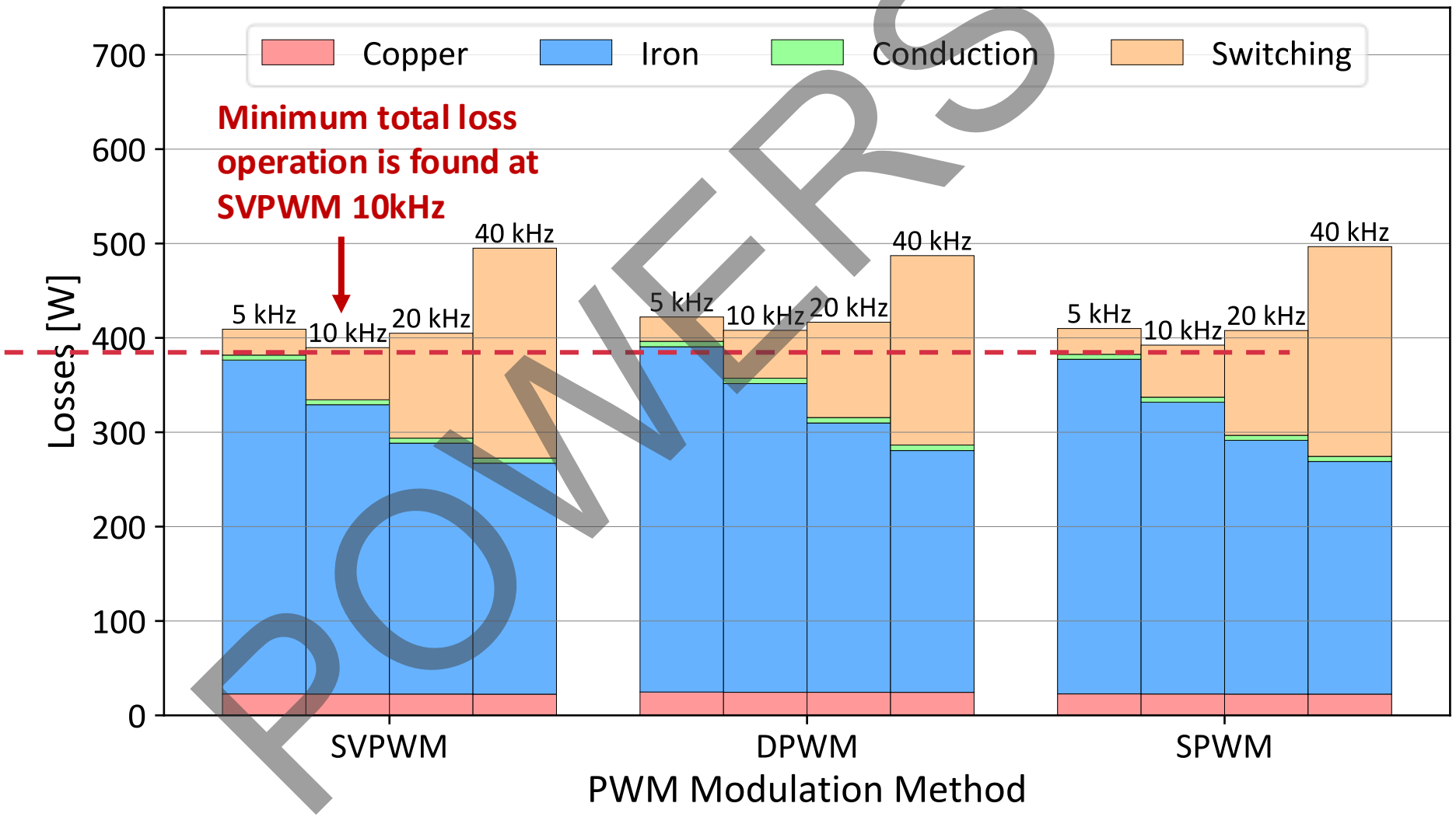
H. Sano *et al.*, "A New AC loss Modeling for Motor Model on MILS Toward Control Parameter Calibrations," *2022 IEEE Energy Conversion Congress and Exposition (ECCE)*, Detroit, MI, USA, 2022, pp. 1-4, doi: 10.1109/ECCE50734.2022.9947654.

Quality Enhancement by High Fidelity Inverter Model



X

Operating Point 2: T = 20 Nm, N = 4000 RPM

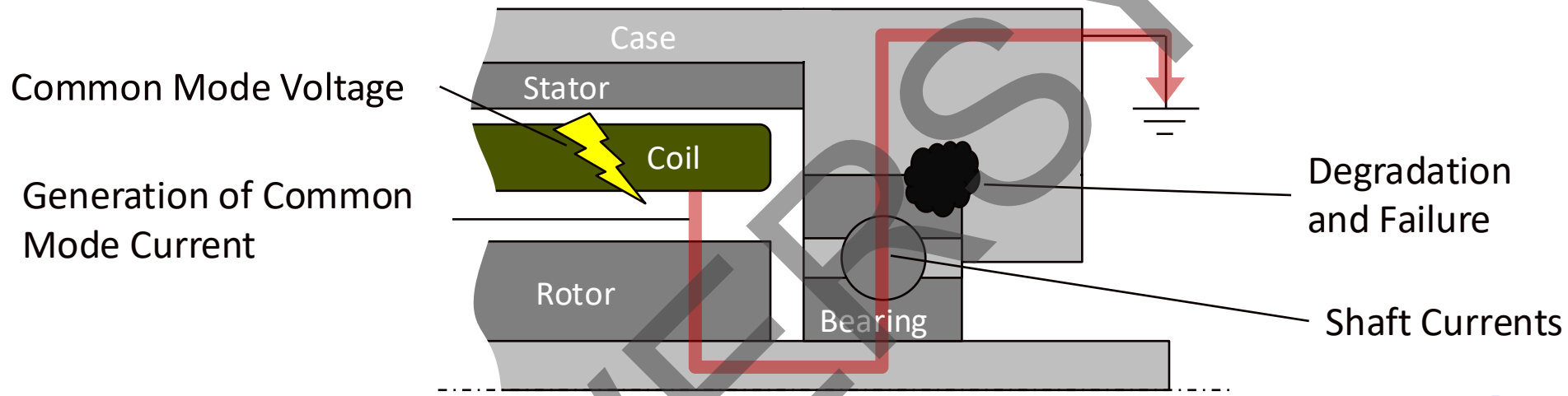


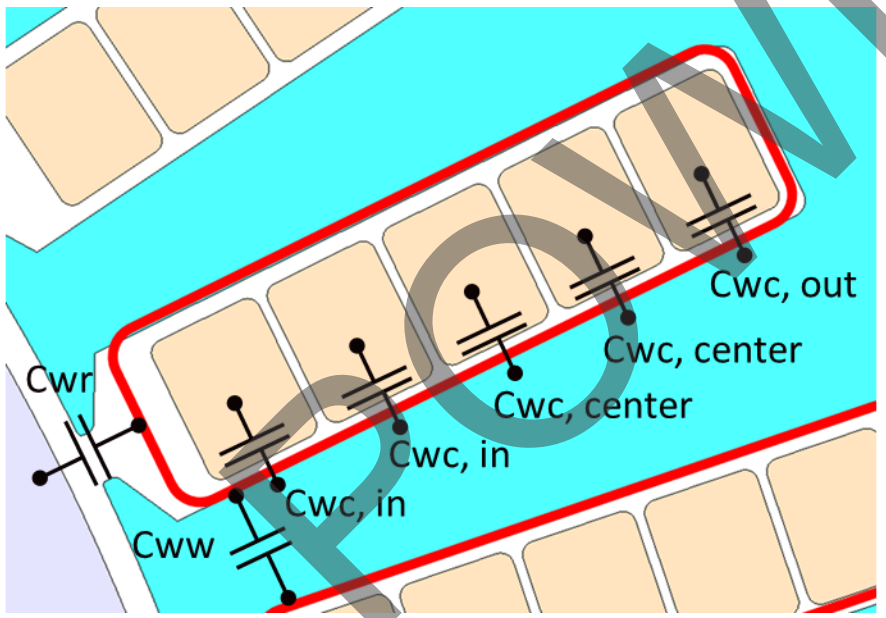
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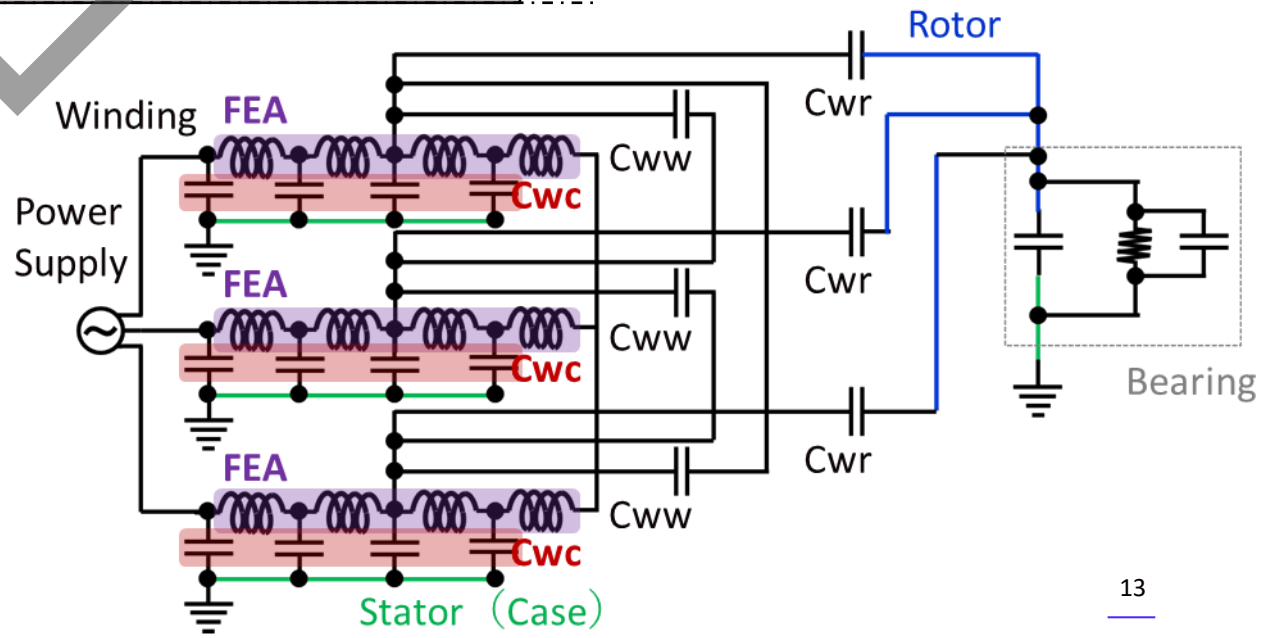
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Challenge in High Quality Data Generation for Motor Inverter System

- Common Mode Voltage and Bearing Current Analysis (W-MO-213)



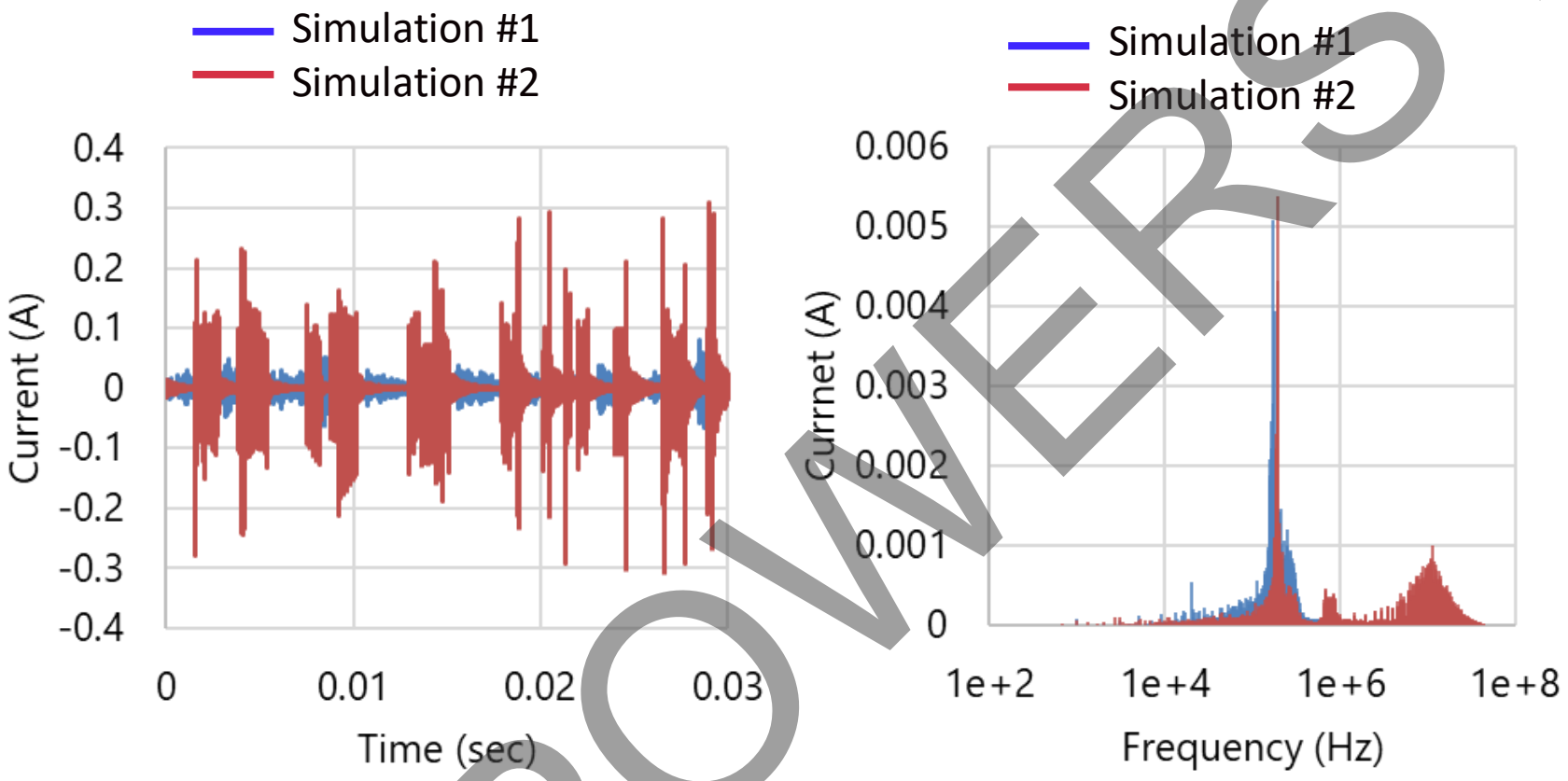




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Challenge in High Quality Data Generation for Motor Inverter System

- Common Mode Voltage and Bearing Current Analysis (W-MO-213)

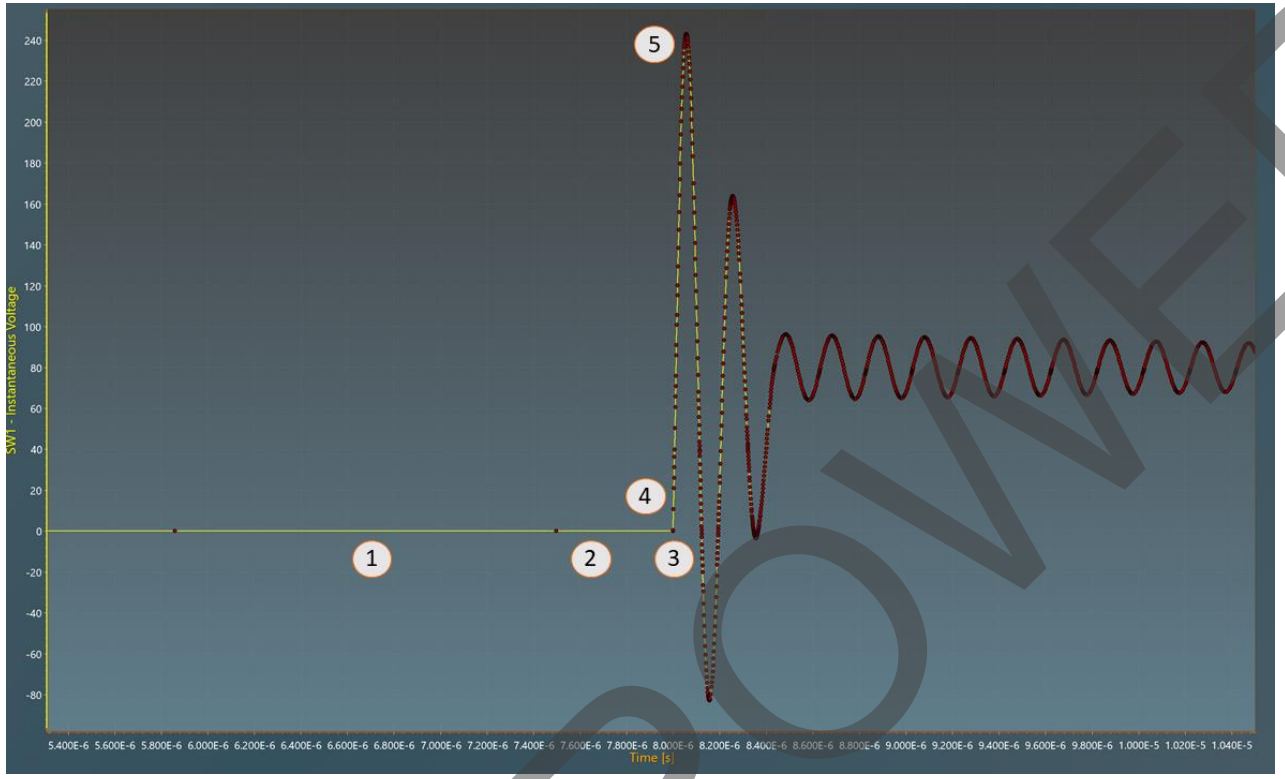


Item	Value
Computer specifications	CPU: Intel(R) Xeon(R) w7-2495X 2.50 GHz; RAM: 128 GB; OS: Windows 11 Enterprise 23H2
Coupling method	JMAG Direct-coupling (co-simulation)
Time step	0.1 (μsec)
Carrier frequency	20 (kHz)
Operating Point	5000rpm, 100Nm
1 electrical cycle	0.003 sec
Number of steps	600,000
Number of elements	13,768
Degree of parallelism	8
Elapsed time	21.1 (h)

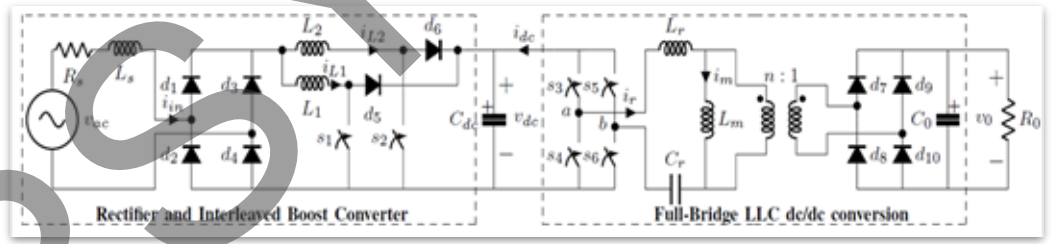
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Fast Data Generation for Motor Drive System

- Predictive Time Step Solver (SIMBA core proprietary)
  - High-precision
  - Minimal User Configuration
  - High-speed
  - Steady-State Detection



Example 1: MOSFET voltage at turn-off in a forward converter (with parasitics)



Example 2: On-Board Battery Charger

	SIMBA	Other power electronics tools
Relative error (max L2 Norm)	0.0501%	---
Simulation time	8 seconds	58 seconds
Calculation points	1,988,464	3,759,001

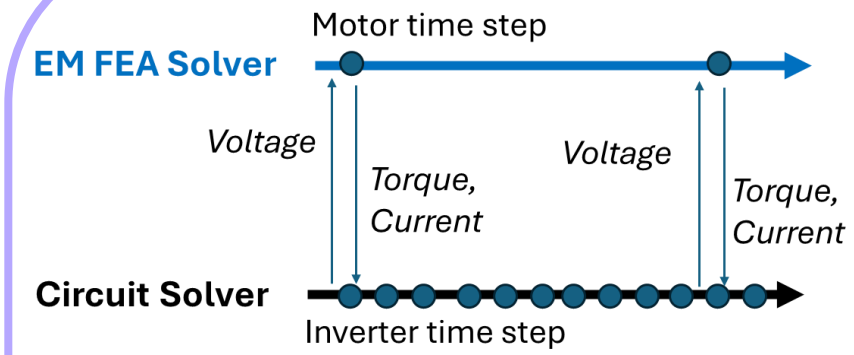
- Achieved similar accuracy
- 85 % of the calculation time reduction

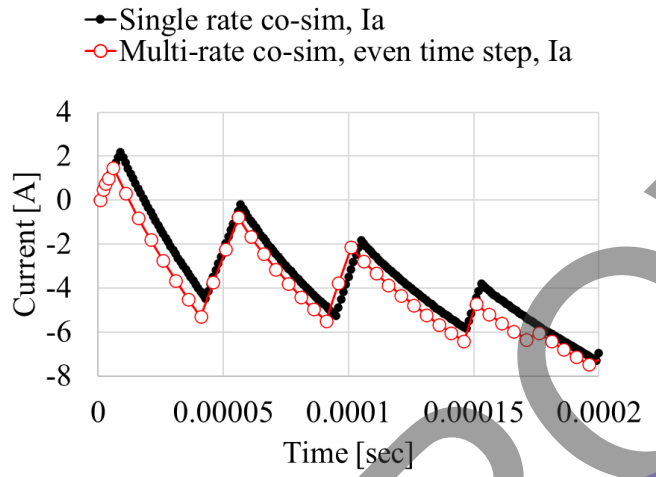
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Fast Data Generation for Motor Drive System

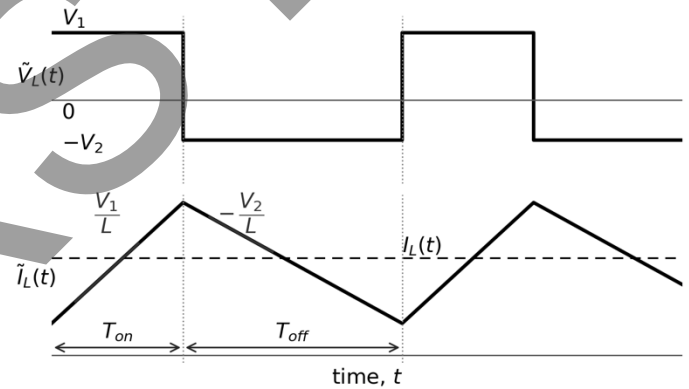
- Direct Coupling Subcycling inspired by small current ripple theory (SIMBA 26.03 update)

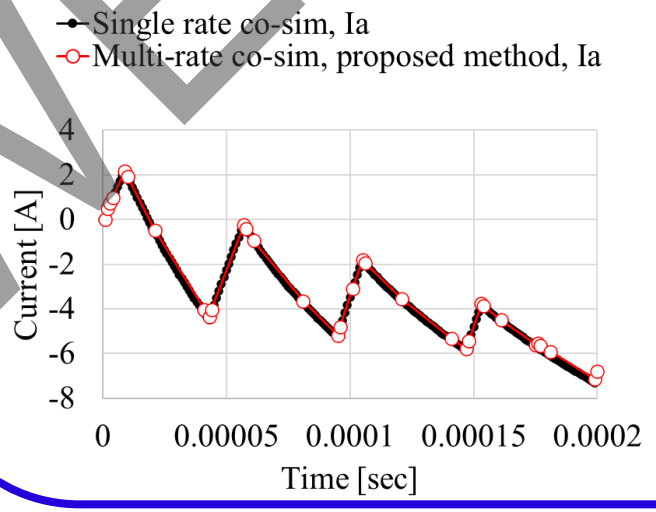
Conventional Subcycling

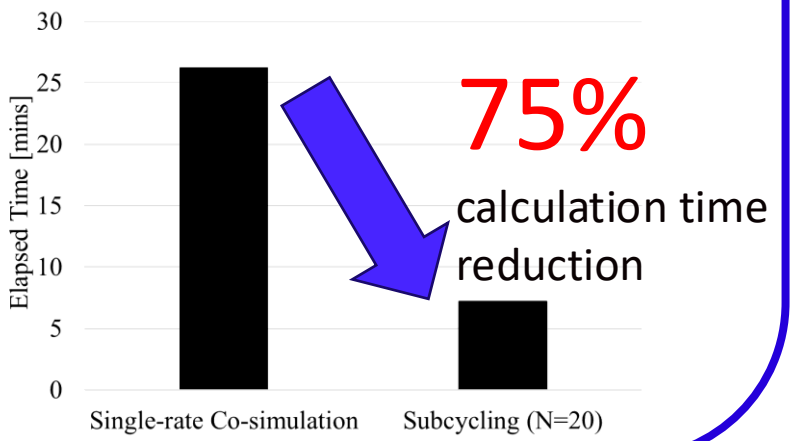




Proposed Approach



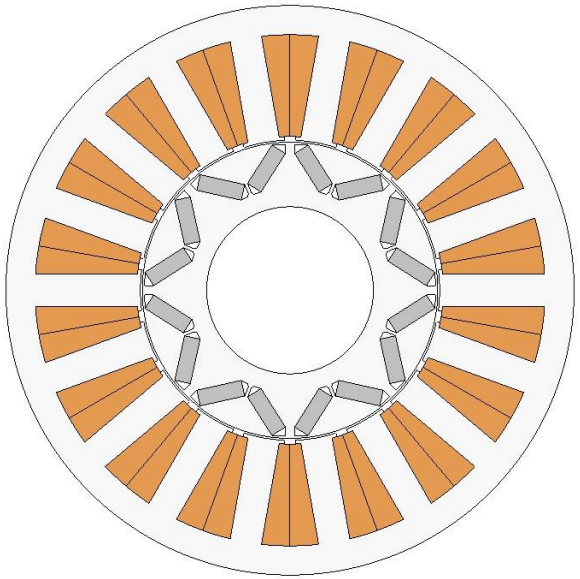


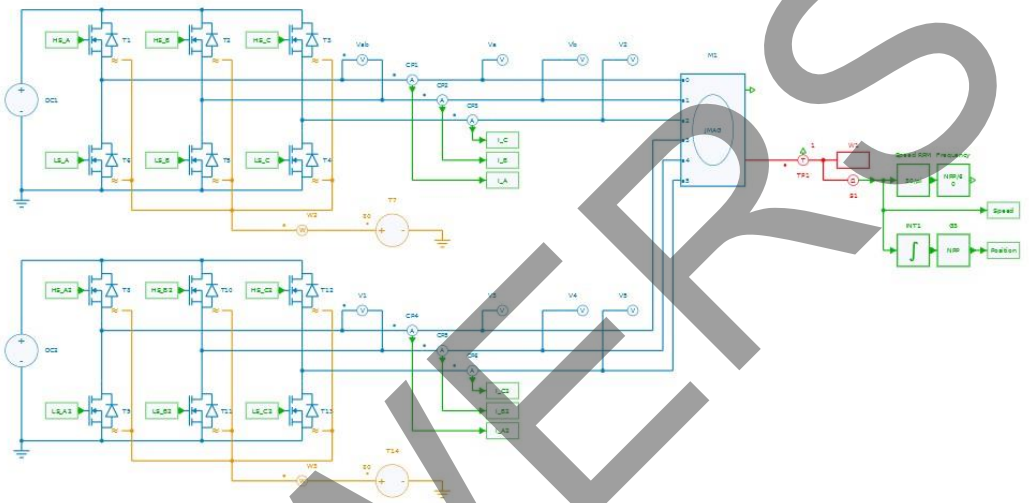


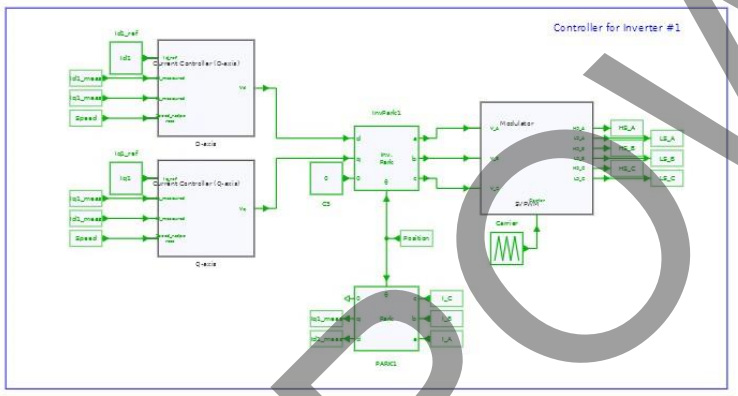
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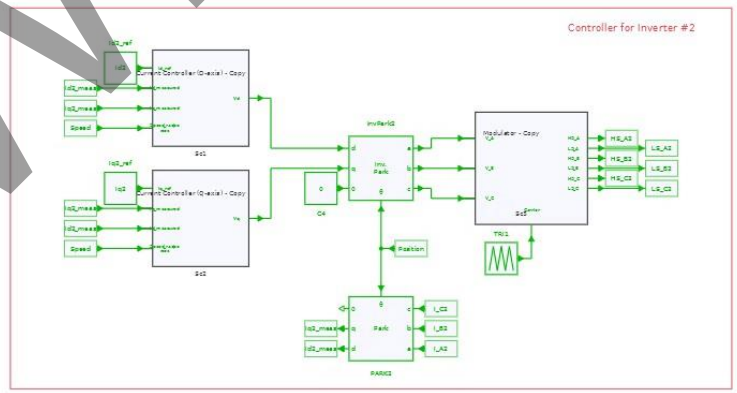
Large-scale Data Generation

- Monte Carlo analysis of MOS-FETs in a dual-three-phase motor drive system using HPC









Monte Carlo method

- An approach to use repeated iterative simulations to model complex probabilistic problems.

Objectives

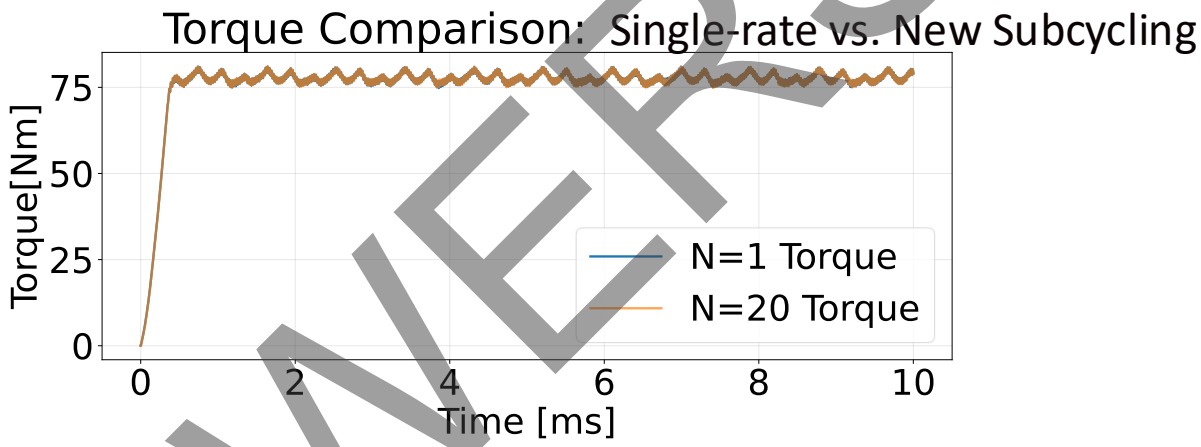
- Evaluate the influence of current distribution on losses and junction templature
- Run 1000 interations
- Each iteration representing one possible scenario

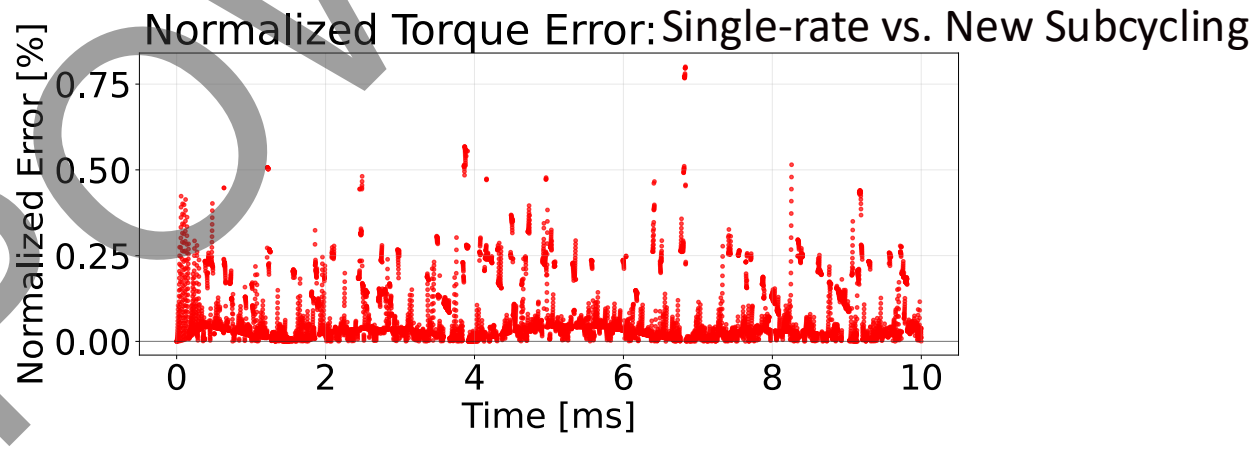
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Dual-Three-Phase Motor Subcycling Test

Single Case Execution

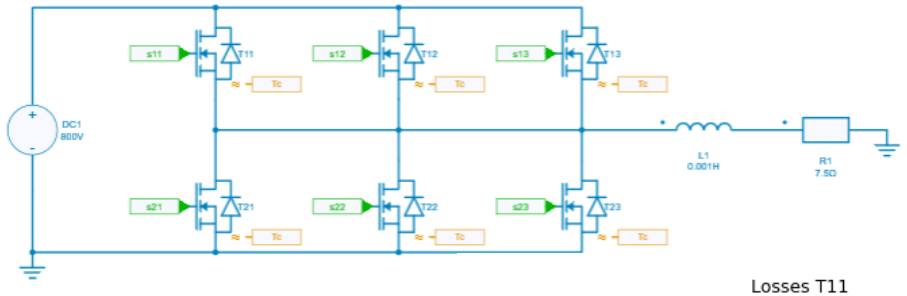
	Single-rate Direct Coupling	New Subcycling (Multi-rate)	Calculation time reduction
Elapsed Times	70 mins	23 mins	68%





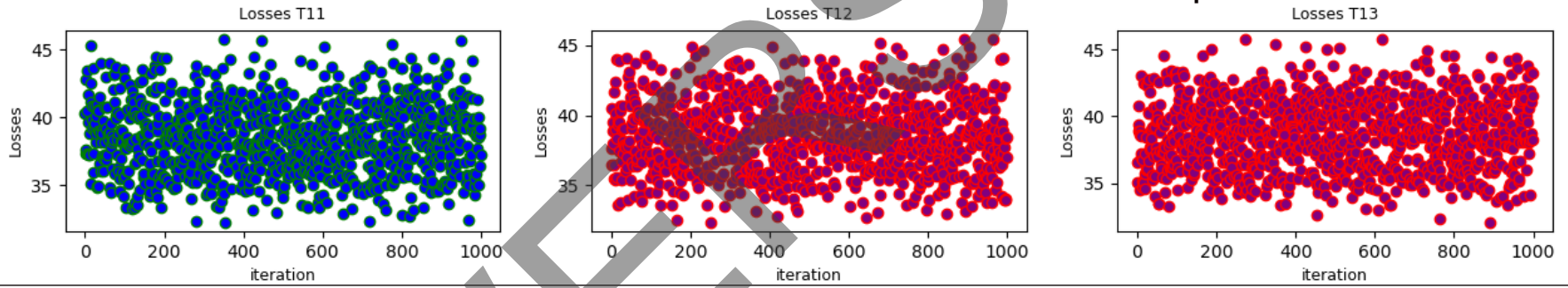
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Monte Carlo Analysis of Parallel MOS-FETs

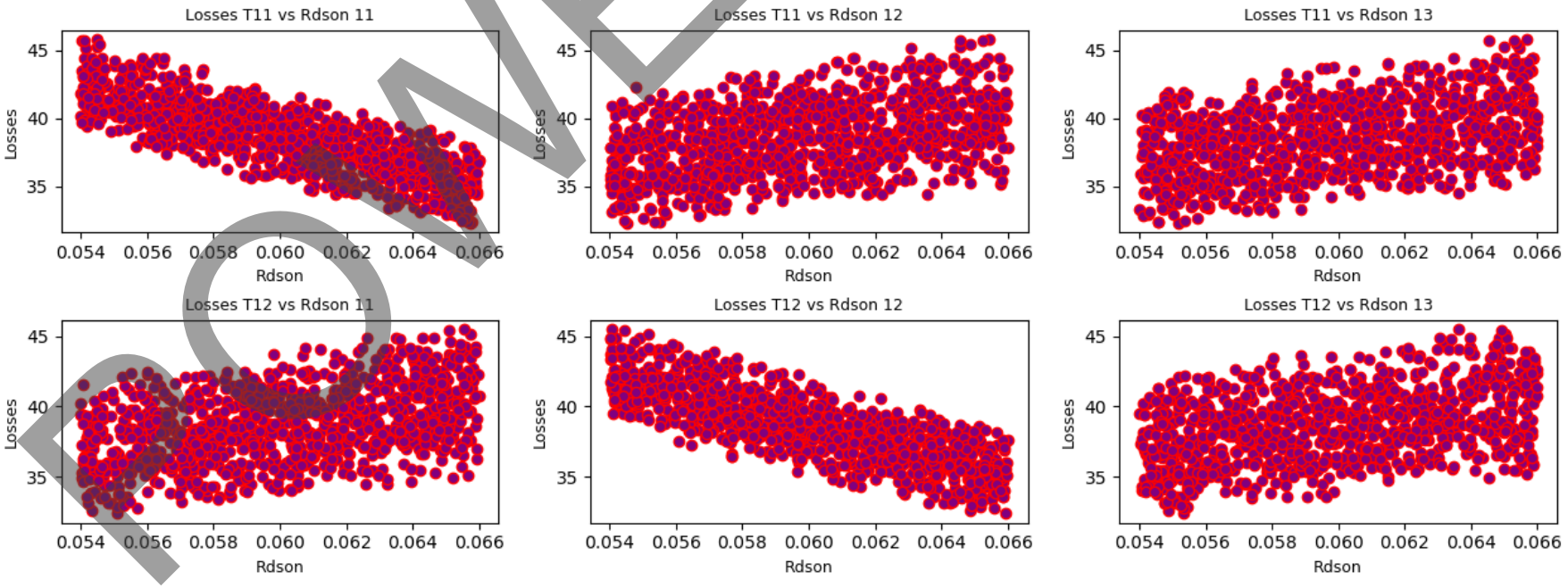


- DC high voltage: 800 V
- Average load current: around 48 A
- Switching frequency: 50 kHz
- Case temperature: 100 °C
- 1000 iterations
- A variation of 10% of two elements for each power MOS-FET

dispersion of losses between the three MOS-FETs.

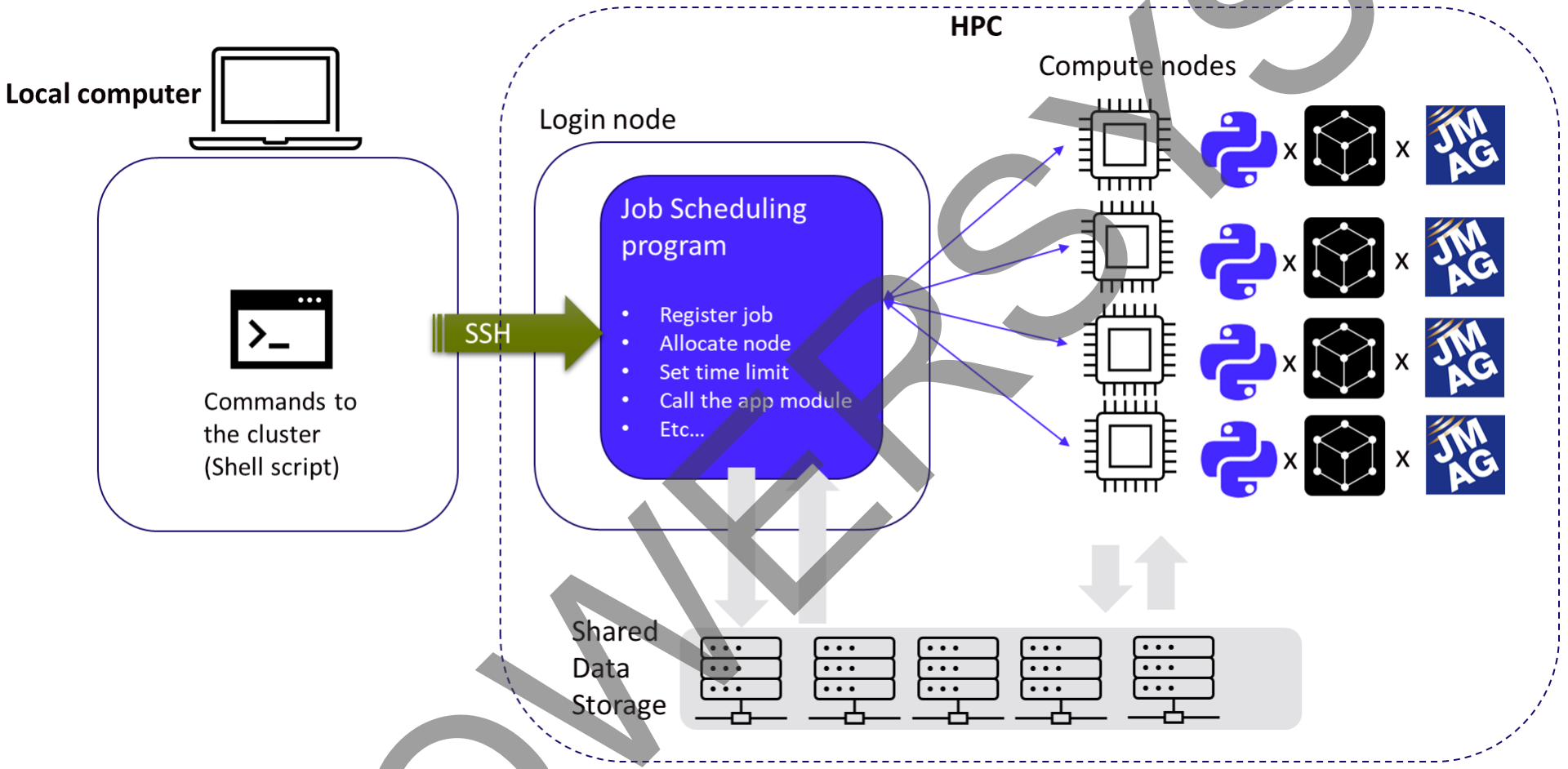


Evolution of losses of the two first MOS-FETs depending on each Rdson



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Large-scale Generation: HPC Structure for JMAG+SIMBA



Estimated Calculation Elapsed Time

Single rate + single core	1000 iterations * 70 mins /60 mins / 24 hours =	48.60	days
With new subsyc + single core	1000 iterations * 23 mins /60 mins / 24 hours =	15.97	days
With new subsyc + parallel 512 cores	1000 iterations * 70 mins /512 cores =	44.92	mins

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Conclusions

- In the era of machine learning and data-driven design, engineers must be able to orchestrate simulations across multiple dimensions—balancing physical fidelity, computational efficiency, and large-scale data management.

- This challenge becomes even more complex when accounting for the interactions between motors and inverters, where trade-offs across these dimensions must be carefully managed.

- Addressing this challenge in motor–inverter drive system is a key focus for the SIMBA–JMAG solution.

- Powersys addresses these challenges with a comprehensive software portfolio and deep expertise across all three areas, built on more than 20 years of customer-driven innovation and engagement.

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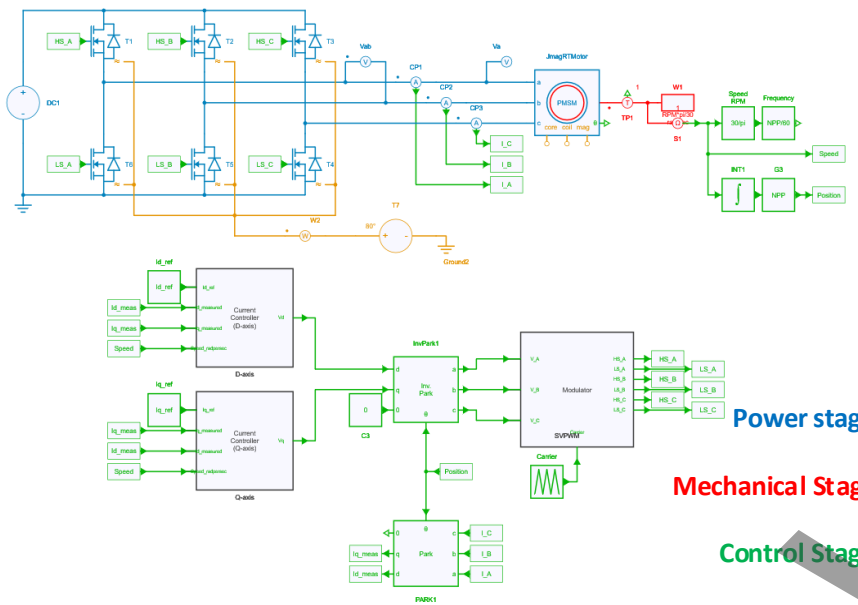
Q & A

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#2 Drive Cycle Simulation (WLTP)

7 minutes long Drive Cycle is simulated in 2 minutes

(using DSET and parallelization across 24 cores)

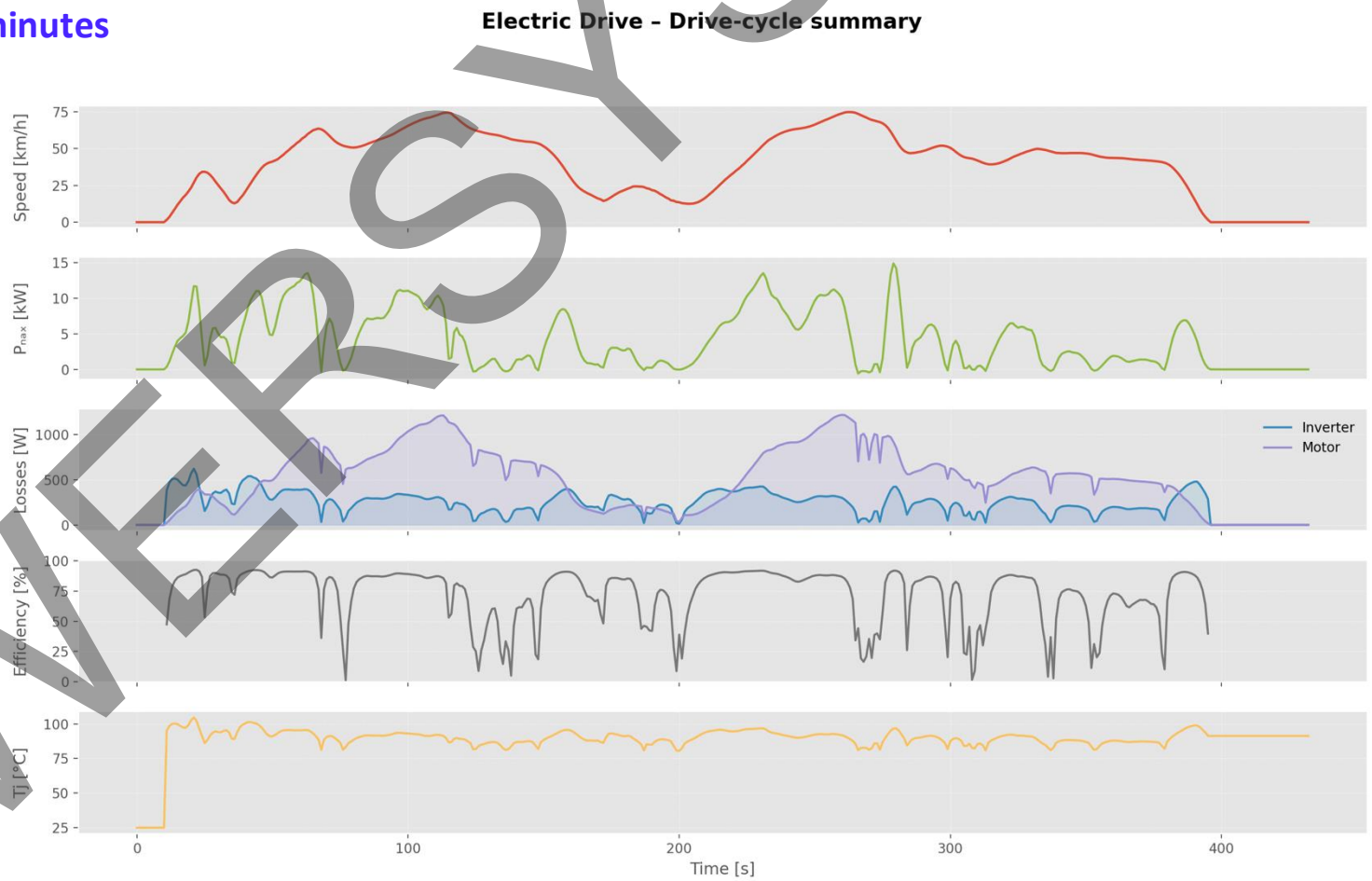


Power stage

Mechanical Stage

Control Stage

Thermal stage



Specs

- 100 kW PMSM motor - JMAG-RT model
- PWM frequency: 50 kHz
- S-PWM + MTPA + flux weakening
- 1200 V SiC module from Wolfspeed

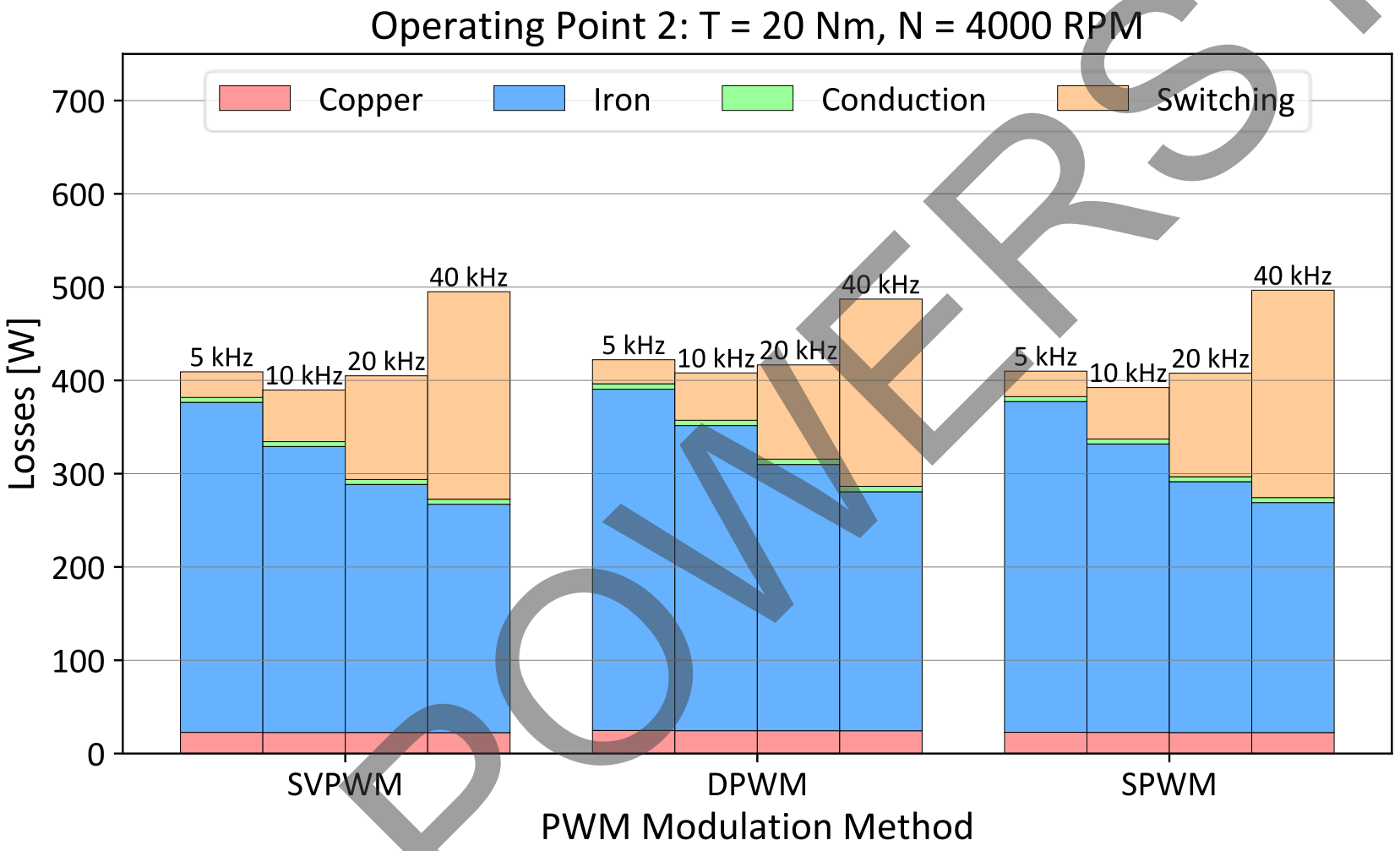
Losses

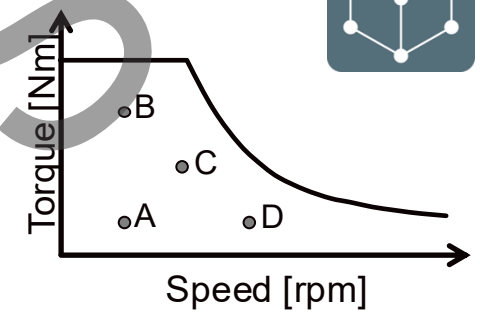
- Motor: calculated with JMAG-RT
- Semiconductor switches : calculated from thermal-description XML files

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High quality dataset example #2

- Drive System Loss Study with Multiple Modulation Techniques

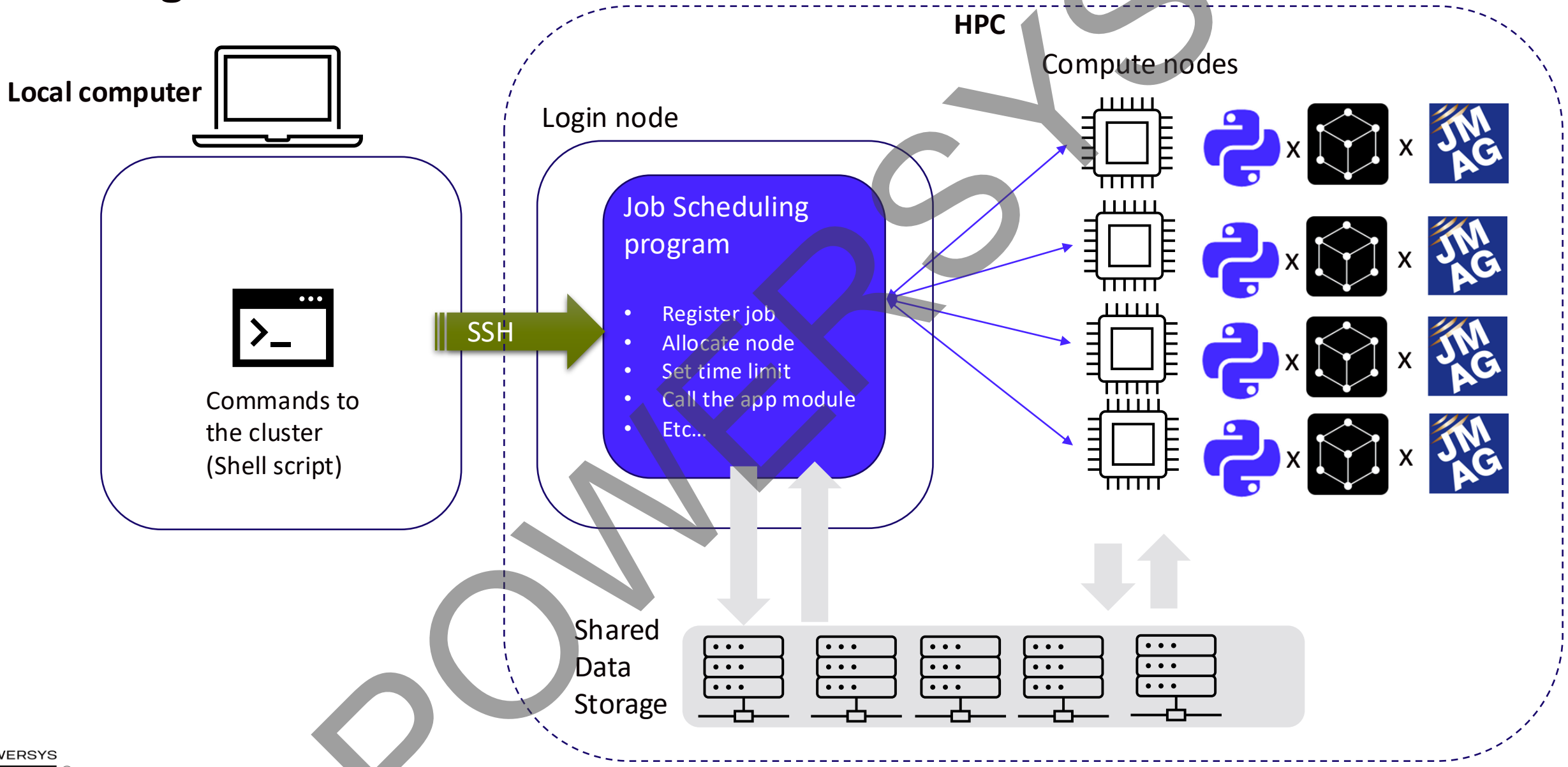




Item	Value
Computer specifications	CPU: AMD Ryzen 7 PRO 8840U, 3.3 Ghz RAM: 32 GB; OS: Windows 11Pro
Coupling method	LUT (JMAG-RT)
Time steps	0.1 (μsec)
Carrier frequency	5-40 (kHz)
Number of steps	250,000
Degree of parallelism	1
Elapsed time	93 (secs) * per case
Number of operating points in rtt file	440 OPs
Rtt file creation time	1.1 (h)

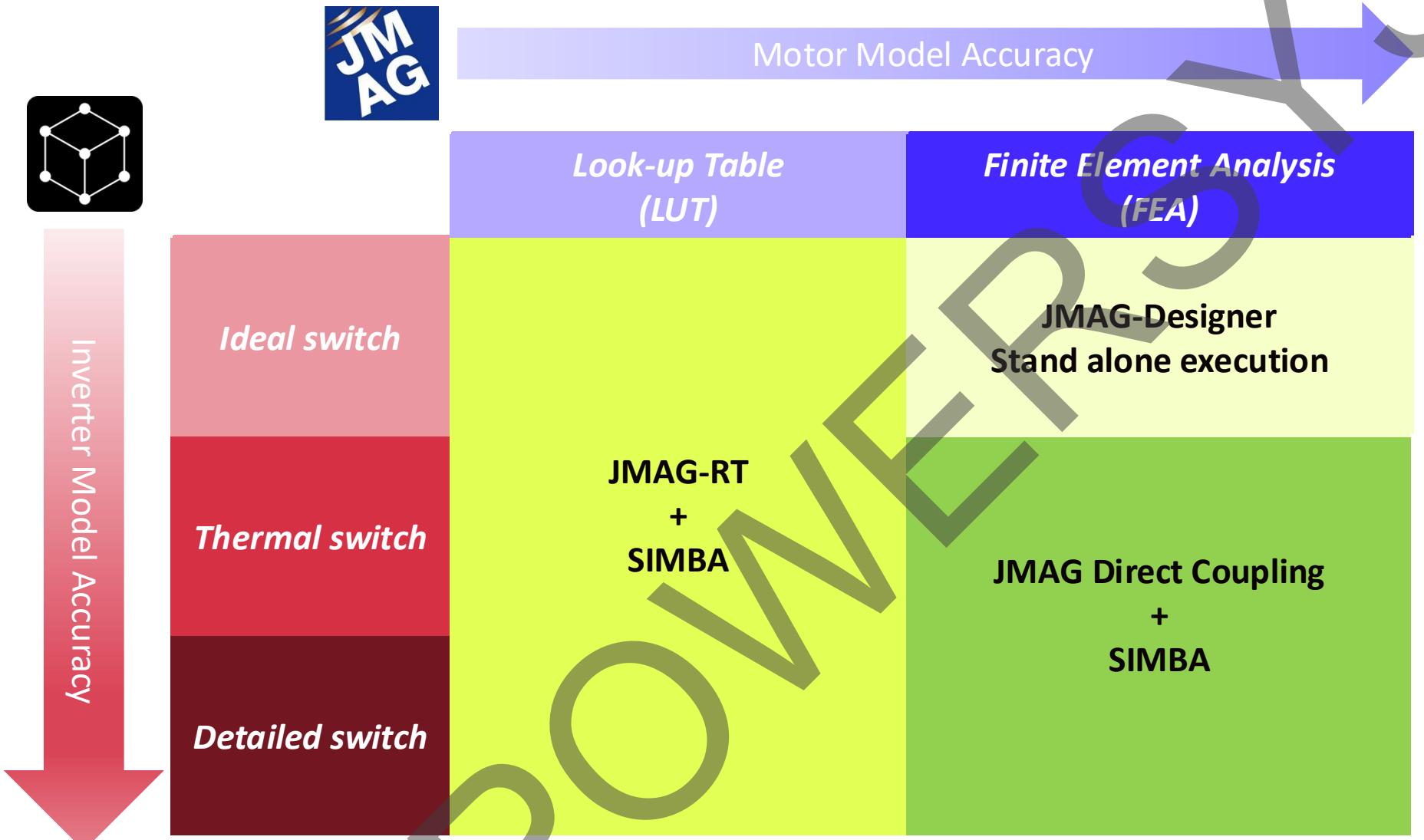
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Large-scale Generation: HPC Structure for EM FEA + PE



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Approaches for Accounting Inverters with JMAG



JMAG-Designer

Uses an ideal inverter model available in JMAG Circuit Editor to capture PWM switching effects in EM analysis.

JMAG-RT Model

Employs lookup tables from FEA data for efficient time-domain system-level PWM simulations and motor parameter estimation.

JMAG Direct Coupling

Co-simulation method to run FEA dynamically exchanging the voltage, current and rotor position with the power electronics tool.

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